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Please amend the Specification in the following manner:

FIELD OF THE INVENTION

[0001] The present invention relates to plant trays/containers, systems and methods of matrix transfer and transplanting of plants/seedlings/plugs to increase plant yields, quality, production efficiency and to reduce the high labor requirement of plant transfer and transplanting to achieve automation of cultural and operational practices both in the field and greenhouse. It is related more particularly to a push-pull air-pruning tray/container structure that allows effective root air-pruning for superior plant growth and that allows plant removal either from the open bottom of the tray or open top of the trays/containers. The present invention further related to a mechanically, pneumatically, hydraulically and/or electrically induced multiple plant/seedling/plug transfer and transplanting systems and methods for matrix transplanting one or more plants/seedlings/plugs from supply trays to the field or to containers using air-pruning trays as integrated components of the matrix transfer and transplanting system.

BACKGROUND OF THE INVENTION

[0002] The rapid increases in demands for higher unit area production and quality crops with less labor have opened worldwide demands for full integration and interfacing of new plant culturing practices and machine systems. Billions of plants/seedlings/plugs/cuttings are transplanted yearly in various sectors of agriculture and forestry with tremendous amount of human labor, causing a major bottleneck in the production systems. Mechanization and automation are as important for plant-growers/farmers as it is for any other field of agriculture. This is because there is a

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tremendous amount of labor involved in the operation of a nursery, and the growers/farmers have to contend with the problems of production efficiency, scarcity of labor and overall labor costs just as any other business.

[00031] In seedling culturing practices one particular labor-intensive area is that of transferring and transplanting relatively young and small plants from their initial rooting containers to larger plant containers or to the field for further growth and development. A great deal of nurseries and plant producing facilities generally perform this operation by hand. Consequently, plant transfer and transplanting are time consuming and very inefficient. As a practical matter, the use of manual labor to transplant such plants severely limits the capacity of a farm or nursery for handling such transfer or transplanting operations. Therefore, there is and continues to be, a need for a fully automatic plant transfer and transplanting system that will automatically transfer and transplant plants/seedlings/plugs from an initial growing tray/container to a transfer area or second container for further growth and development in order to produce a superior plant in a greenhouse or in the field. Labor cost and availability, high costs of automation, as well as the inherent difficulties of plant/seedling/plug/cutting handling with a mechanical gripper (the main cause of misses, damages and unreliability) are the key problems to be resolved.

[00041] The innovative plant root-air-pruning technologies invented by Dr. Barney K. Huang have demonstrated many advantages including: elimination of root-binding, promotion of properly oriented root-branching for increased root-mass and vigorous growth, increased yields and quality, increased utilization cycles of greenhouse facilities, and savings on growth media, energy and fertilizer. The root-air-pruning

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concept allows the development of unique trays that lends itself to a simple automated/robotic transplanting system such as that disclosed by Dr. Barney K. Huang in U.S. Pat. Nos. 5,179,800, 5,254,140, 5,298,041, 5,573,558 and 6,357,180. Air-pruning tray-cells/pots has open bottoms with detachable screens. The tray-cells/pots are larger at the bottom and smaller at the top to eliminate the inherent disadvantages of traditional tray-cells/pots that have smaller closed bottom with drain hole(s) and larger open top that makes the container-sidewall tapered outward toward the top resulting in improper sidewall angle to cause root binding (root spiraling and tangling), slow and non-uniform growth.

[0005] The air-pruning tray-cell/pot/container design also utilizes the plant shoot characteristic that allows the foliage to fold together to go through the cell opening as the plant is pulled from the bottom or pushed from the top. This plant characteristic lends itself to an easy dislodging of the plant from the open cell/pot bottom and to the fully automated transplanting without using any types of grippers. Practical large scale field applications indicated that air-pruned cuttings and seedlings are significantly superior in growth performance both in the trays/containers and after transplanting and that effective fully automatic transplanting can be performed with the air-pruned plants/seedlings/plugs for various crops. However, many growers/farmers currently own transplanting machines and equipment, which were designed for traditional trays/flats/pots, yet, they want to use air-pruning trays/flats/pots which provide them with increased plant production, quality and yields. Therefore, there has been and continues to be a need for air-pruning trays/flats/pots that effectuate air-pruning but will

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allow the plugs/seedlings/plants to be removed from the top of air-pruning trays/flats/pots.

SUMMARY AND OBJECTS OF THE INVENTION

[0006] The present invention entails plant growing air-pruning trays/pots/containers and the matrix transfer and transplanting systems and methods that are designed to overcome the disadvantage and shortcomings of many prior arts. In particular, the air-pruning trays/pots/containers of the present invention is provided with a tray-cell/pot/container structure that allows plant removal either from the open bottom of the tray/pot or open top of the tray/pot and with a detachably supporting bottom screen that effectuates root air-pruning. The manually, mechanically, pneumatically, hydraulically and/or electrically actuated plant transfer and transplanting system is operative to receive air-pruning supply trays having a plurality of plants/seedlings/plugs—therein, transferring and transplanting one or more plants/seedlings/plugs at a time from the supply trays utilizing push-rod or impulse type vacuum forces or other means to remove plants/seedlings/plugs from tray-cells/pots and eject or push them onto transfer areas such as the field ground or other plant containers.

[0007] It is therefore an object of the present invention to provide an air-pruning tray/pot/container structure that allows plant removal either from the open bottom of the tray/pot or open top of the tray/pot and with a detachably supporting bottom screen that effectuates root air-pruning. It is also an object of the present invention to provide a simple and low cost plant transferring and transplanting system for transplanting one or more plants/_seedlings/plugs from one container or a supply tray/pot to a transfer area or second container.

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[0008] ~~Another object of the present invention resides in the provision of an automatic transferring and transplanting system that utilizes an intermittent or impulse vacuum system for inducing the movement of a plant/plug or a plurality of plants/seedlings/plugs from a supply tray/pot to the field or containers to achieve fully automated transplanting.~~

[0009] ~~Another object of the present invention is to provide a matrix transfer and transplanting system for automatically transferring groups of plants/plugs from an open bottom supply tray/pot by manually, mechanically, pneumatically, hydraulically and/or electrically pushing selected plants from and through the open bottom of the supply tray.~~

[0010] ~~A further object of the present invention is to provide a manual or automatic plant transfer and transplanting system using air-pruning trays as integrated components of the matrix transfer and transplanting method for the system. One group of plants forming a matrix within, one or a group of supply air-pruning trays is transferred and thereafter the entire supply tray or-trays-is sequentially shifted to a second position such that another like matrix of plants can be transferred and wherein this process is continued until the entire supply tray or-trays-are-is emptied.~~

[0011] ~~Still a further object of the present invention is to provide an automatic plant transfer and transplanting system that is relatively simple and portable in construction and which is reliable and easy to use.~~

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[0012] Other objects and advantages of the present invention will become apparent and obvious from a study of the following description and the accompanying drawings, which are merely illustrative of such invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG.1 is a perspective view of the matrix transfer and transplanting system according to an embodiment of the present invention illustrating that air-pruning trays (supply trays) are integrated components of the system and that it can transplant 2 pots at a time using 2 impulse vacuum systems or 2 flats at a time using 2 sets of push rods arranged in matrix formation.

[0014] FIG. 2 is a side view of a supply tray on an upper table according to an embodiment of the present invention. shows the operational principle of the plant transfer and transplanting system

[0015] FIG. 3 is a side view of a portion of the system according to an embodiment of the present invention shows the operational principle of the plant transfer and transplanting system of the present invention illustrating that multiple plants are instantly dislodged downward and transplanted into multi-air-pruning pot flat with push-rod forces as the open bottoms of tray cells match the openings of indexing table.

[0016] FIG. 4 shows an exemplary plant removal mechanism according to an embodiment of the present invention. the pneumatically or hydraulically activated impulse vacuum system of the present invention with suction tube at the center of round bellow (with flexible door at the end) activated by two cylinders to generate impulse vacuum.

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[0017] FIG. 5 shows an exemplary plant removal mechanism according to another embodiment of the present invention, the pneumatically or hydraulically activated impulse vacuum system of the present invention with a square pyramid shaped bellow.

[0018] FIG. 6 through FIG. 11 illustrate a side view of the system during operation according to an embodiment of the present invention. are a sequence of front elevation views of an automatic transplanter of the present invention illustrating a series of matrix plant transfers and transplanting from an air pruning supply tray to an underlying multi-pot receiving flat with FIG. 6 illustrating the initial positions of upper and lower indexing tables, relative locations of air pruning trays, underlying flats, pushers and dibblers. The first flat has been dibbled) and the second flat is ready to be dibbled by moving the lower table upward; FIG. 7 illustrating the dibbling operation is completed for the second flat while the first flat is ready for transplanting. The upper and lower tables move upward together to complete the transplanting operation for the first flat with the stationary pushers above; FIG. 8 illustrating both tables being moved upward to a preset point so that all seedlings for the first flat are transplanted by pushers to flat soil level in one operation. While pushers hold down the seedlings) the upper table moves upward to a preset point to clear the seedlings; FIG. 9 showing the transplanting operation for the first flat and dibbling operation for the second flat are completed and both tables are moving downward back to the initial table positions shown in FIG. 6; FIG. 10 showing both tables are at the initial position and the first flat is ready to be conveyed out) allowing the second flat moving into transplanting position and the third set of flat to be conveyed into dibbling position; and finally FIG. 11 illustrating the first

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~~flat is conveyed out and the second flat is ready for transplanting and the third flat is ready to be dibbled.~~

[0019] FIGS. 12 and 13 illustrate a plant transfer and transplant configuration according to one embodiment of the present invention. respectively illustrate the beginning and final positions of 288-cell air pruning tray being sequentially indexed for matrix transfer and transplant 2 x 4 multi-pot flat or 8 plants at each indexing.

[0020] FIGS. 14 and 15. illustrate a plant transfer and transplant configuration according to another embodiment of the present invention. respectively illustrate the beginning and final positions of 288-cell air pruning tray being sequentially indexed for matrix transfer and transplant 3 x 6 multi-pot flat or 18 plants at each indexing.

[0021] FIGS. 16 and 17 illustrate a plant transfer and transplant configuration according to another embodiment of the present invention. respectively illustrate the beginning and final positions of 288-cell air pruning tray being sequentially indexed for matrix transfer and transplant 4 x 8 multi-pot flat or 32 plants at each indexing.

DETAILED DESCRIPTION OF THE INVENTION

[0022] With reference to FIG. 1, the automatic matrix transfer and transplanting system of the present invention indicated generally by the numeral 100, includes a plant supply tray ~~the~~ push-pull air-pruning trays 10, ~~the~~ an upper indexing table 20 with interchangeable opening plates 21 and matching dibbler plates 22, ~~the~~ an X-y indexing frame 23, ~~the~~ a lower indexing/conveying table 30, ~~the~~ a indexing/conveying belt 31, a supporting frame 40, ~~and~~ a plant extraction mechanism, such as ~~as~~ detachable impulse vacuum systems 50, and interchangeable push-rod plates 60 and pushers 61. As will

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be appreciated from subsequent portions of this disclosure, the plant/plug supply tray 10 can be an air-pruning tray that forms a part of the transplanting system designed to transfer one or more plants at a time from a the supply tray 10 to a receiving area such as pots, multi-pot flats or the field environment.

[0023] The matrix transfer and transplanting system 100 is designed to receive a one or more supply trays 10, each of which that includes an open top and bottom and a plurality of aligned and uniformly spaced truncated pyramid or generally cone-shaped plant cells 11 formed in the tray, as shown in FIG. 2, to hold plants. Matrix transfer and transplanting system 100 is designed to transfer respective the plants/seedlings/plugs from the supply tray 10 to the plant receiving areas in a matrix formation, which can be individually separated pots, multi-pot flats, and the field environment.

[0024] Turning now to a discussion of matrix transfer means 100, the same comprises a supply tray holding indexing means 23, According to one embodiment, the upper indexing table 20 that includes therein one or more matrix openings means 21 as shown in FIGS. 2 and 3. The matrix openings means 21 could include a single opening or a plurality of openings that are particularly spaced can be arranged to correspond to one or more with respect to the individual cells 11 of the supply tray 10. This allows selecting cells 11 of the supply tray 10 to align with matrix openings 21 when the supply tray assumes a selected position thereover. In any event, as will be understood and appreciated from subsequent portion of this disclosure, the function of the openings means 21 is to permit selected plants/seedlings/plugs to be removed pass therethrough as they are dislodged from the supply tray cells 11. To contain and control the movement of the supply tray 10, matrix transfer system 100 comprises X-y-type the

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indexing frames 23 shown in FIG. 1. The indexing frame 23 includes frames that are movably mounted over the table 20 of the matrix transfer system 100 and for receiving, holding and indexing the supply tray 10. The indexing frames 23 can be indexed in X or y direction about the table 20 manually or via using electrical, hydraulic, pneumatic, mechanical and/or manual means.

[00251] Also forming a part of the matrix transfer means of the present invention is According to one embodiment of the present invention, the lower indexing/conveying table 30 and indexing/conveying belt 31. It functions to align transfer the respective plant receiving means area 32 to an appropriate planting position under the plant extraction mechanism, e.g., suction tubes 51 or pushers 61, where the transfer of plants actually takes place, and under the dibblers 22, as shown in FIG. 3, where the dibbling of growth media takes place. It is appreciated that the indexing/conveying belt 31 would be operated in time relationship to the indexing frame 23. In this regard it should be appreciated that matrix transfer system 100 of the present invention is designed so as to plant all of the underlying plant receiving means area 32 at the same time with one or more single-/multi-tubes 51 or one or more single-/multi-pushers 61 for one or more one-/multi-plants at a time, with the indexing/conveying table 30 and indexing/conveying belt 31. Once the underlying plant receiving means area 32 has been planted, then the indexing/conveying belt 31 is operative to advance these the plants and associated containers from a planting position underneath the upper indexing table 20. Right after As the plants planted containers have been are moved from the planting position underbeneath the upper indexing table 20, the indexing/conveying belt 31 is operative to advance a next receiving area 32 is

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advanced group of containers to the planting position underbeneath the upper indexing table 20. Thus, the next receiving area 32 is ready to receive another batch of plants from the supply tray 10.

[0026] Turning now to FIG. 4, which shows the pneumatically or hydraulically activated-impulse vacuum system 50 is shown according to one embodiment of the present invention indicated generally by the numeral 50. The vacuum system 50 includes a The suction tube 51 is attached at the upper center of a round bellow 52 and the lower end is attached to the a telescoping tube inside the bellow 52 with a flexible door 53 at its end. The bellow 52 is activated by two cylinders 54 to generate impulse vacuum at the suction tube 51 as the bellow 52 is expaended by activating the cylinders 54 which causes the flexible door 53 to close automatically. In another embodiment, shown in FIG. 5, the impulse vacuum system 50 includes a The alternative-square pyramid shaped bellow 52 and the means of activation is shown in FIG. 5. The pyramid shaped bellow 52 tends to provide a larger initial impulse vacuum.

[0027] Turning to the operation of the matrix transfer and transplanting system 100 of the present invention, reference is first made to FIG. 6 through FIG. 11 are diagrams of an exemplary system during an operational sequence according to one embodiment of the present invention. that illustrate a sequence of automatic transplanting illustrating a series of matrix plant transfers and transplanting from an air pruning supply tray 10 to an underlying multi-pot receiving flat 32. The sequence of plant transfer and transplanting starts with FIG. 6 shows illustrating the initial positions of the upper table 20 and the lower indexing conveying tables 20 and 30, relative locations of air pruning the plant supply trays 10, a first plant receiving areaunderlying flats 32A

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and a next receiving area 32B, pushers 61 and dibblers 22. The first flat receiving area 32A has been dibbled, and the second flat receiving area 32B is ready to be dibbled by moving the lower conveying table 30 upward. ; FIG. 7 illustratesing the dibbling operation is completed for the second flat receiving area 32B while the first flat receiving area 32A is ready to receive one or more plants from the supply tray 10 for transplanting. The upper table 20 and lower conveying tables 20 and 30 move upward together toward the stationary pushers 61 above to complete begin the transplanting operation for the first flat receiving area 32A, with the stationary pushers 61 above; FIG. 8 illustrating shows both tables 20 and 30 being moved upward to a preset point so that all seedlings plants for the first flat receiving area 32A are transplanted by pushers 61 to flat soil level in one operation. In one embodiment, while pushers 61 hold down the seedlings plants, the upper table 20 moves upward to a preset point to clear the seedlings. ; Once FIG. 8 showing the transplanting operation for the first flat receiving area 32A and dibbling operation for the second flat receiving area 32B are completed, and both tables 20 and 30 are moving moved downward back to the initial table positions (FIG. 9). shown in FIG. 6; FIG. 10 showing Once both tables 20 and 30 are at the initial position, and the first flat receiving area 32A is ready to be conveyed out, allowing the second flat receiving area 32B to move moving into transplanting position and the a third flat receiving area 32C to be loaded conveyed into the dibbling position, as shown in FIG. 10 and FIG. 11. ; and finally FIG. 11 illustrating the first flat 32A is conveyed out and the second flat 32B is ready for transplanting and the third flat 32C is ready to be dibbled.

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[0028] It should be appreciated that the matrix transfer and transplanting system of the present invention can be adapted to accommodate various size plant trays 10 and multi-pot flats 32 with varying numbers of plant cells and pots formed therein. For example, As illustrations FIGS. 12 and 13 respectively show the beginning-initial and final positions of a 288-cell air-pruning tray 10 being sequentially indexed to transfer and transplant 2 x 4 multi-pot flat 32 in matrix formation or 8 plants into a matrix formation at each indexing, ; FIGS. 14 and 15 respectively illustrate show the beginning-initial and final positions of the 288-cell air-pruning tray 10 being sequentially indexed to transfer and transplant 3 x 6 multi-pot flat 32 in matrix formation or 18 plants into a 3 x 6 multi-pot flat 32 in matrix formation at each indexing, ; and FIGS. 16 and 17 respectively illustrate show the beginning-initial and final positions of the 288-cell air-pruning tray 10 being sequentially indexed to transfer and transplant 4 x 8 multi-pot flat 32 in matrix formation or 32 plants into a 4 x 8 multi-pot flat 32 in matrix formation at each indexing. Once the supply tray 10 comes to the final position, i.e., or all plants/seedlings/plugs has have been transferred and transplanted, then the empty plant supply tray 10 is removed from the indexing frame 23, and . A new loaded plant tray 10 can be is placed within the indexing frame 23 or supply tray holding and indexing means 23.

[0029] From the foregoing specification and discussion it is appreciated that the present invention entails a plant tray/container system that lends itself to air-pruning and automated matrix transfer and transplanting with manual or machine operation. The air-pruning tray becomes part of plant transfer and transplanting system for an effective and efficient operation.